



**UNITED STATES ARMY
ENVIRONMENTAL HYGIENE
AGENCY**

ABERDEEN PROVING GROUND, MD 21010

MICROWAVE LEAKAGE PROBE SYSTEM

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DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

HSE-RL/WP Technical Guide (Med)

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MICROWAVE LEAKAGE PROBE SYSTEM

1. BACKGROUND. Army depot and certain maintenance facilities and laboratories have a requirement to measure the leakage levels of microwave energy from high power waveguide transmission lines, transmission line components or dummy loads. Such a requirement usually exists during extensive testing of high power radar and communication systems in dummy loaded or free space radiation test configurations where leakage could develop. This Agency has made recommendations concerning such testing, with particular reference to optimum types of test equipment, acceptable and safe procedures, and maximum allowable leakage levels. This document presents a summary of those recommendations, and may be considered applicable in the general case.

2. TEST REQUIREMENTS. Virtually all high power microwave systems operating above 1 GHz utilize waveguide transmission lines for energy transfer within the system. Both rigid and flexible waveguide is easily damaged, and if a fracture occurs, radiation leakage will result. Since extensive quantities of energy are often involved, even a small percent of leakage can produce a potentially hazardous power density level. On the other hand, even large leakage levels, when radiated, attenuate rapidly with distance, since a waveguide leakage source represents a small, low-gain antenna aperture. Any probing for suspected leakage will require a sensitive yet wide amplitude range measuring instrument, utilizing a low-gain or small aperture antenna. Probing will normally be done right along the surface of the transmission line or related component. As with all measurement systems, calibration of the instrumentation is a requirement.

3. LEAKAGE PROBE SYSTEM.

a. The attached Plate gives a schematic diagram of a measuring system that will meet the requirements under discussion. An adequate power meter/detection combination will be one which is calibrated for the appropriate frequency and which has a 10 mW full scale capability. Where an attenuator is required (see the selection chart on the Plate), it must also be one which is calibrated over the frequency band of interest. The waveguide-to-coax adapter, which serves as the antenna for the leakage probe system, is also chosen from the selection chart as a function of frequency, and does not require calibration. Note that all of the components required for the system will normally be calibrated shelf items in the typical facility which has a need to utilize leakage probe measurements. There should be no requirement for the purchase or special calibration of equipment in order to implement this system.

b. An example is presented here to illustrate the use of the system. A facility is final testing the AN/TRC-112 troposcatter communication radio set. A dummy load has been attached outside the transmitter van, in place of the antenna assembly. The requirement exists to probe the waveguide transmission line and dummy load for microwave leakage. The AN/TRC-112 has a 1300 W average power output capability and operates over the frequency range of 4.4 to 5.0 GHz. This system uses the WR-187 rectangular waveguide with outside dimensions approximately 5 cm x 2.5 cm. From the selection chart the frequency band of 4.4 to 5.0 GHz is seen to fall within the band of the WR-187 waveguide-to-coax adapter (3.95 to 5.85 GHz). The selection chart also recommends the use of a 10 dB series attenuator. Use of the attenuator is optional; however, it should be noted that the last row of the selection chart has included this attenuator in stating the indicated power for a 1 mW/cm² leakage level. If the attenuator is included, 1.20 mW indicated power x 10 (accounting for 10 dB attenuation) is 12.0 mW actual power. 12.0 mW x .0840 (correction factor) is 1.0 mW/cm² leakage level. The WR-187 waveguide-to-coax adapter, the 10 dB attenuator and the microwave power meter are used as a probing system and the adapter is moved along the surface of the transmission line under test. Loose coupling is recommended - approximately 1 to 2 cm spacing should be maintained between the adapter and the transmission line. Wherever a reading is obtained, the adapter should be rotated, tilted, etc., for maximum power meter indication. Finally, the power meter indication, multiplied by the attenuation value (x 10 for 10 dB, x 100 for 20 dB, x 1 for None) and multiplied by the correction factor (.0840 for WR-187) gives the leakage level in mW/cm².

CAUTION

Microwave leakage from severely damaged waveguide or loose flanges of the AN/TRC-112 system could produce potentially hazardous power density levels to a range of two meters (worst case - open waveguide).

When the measurement is complete, a permanent record should be made, indicating the worst leakage levels encountered. Regions showing greater than 1.0 mW/cm² leakage should be examined (SYSTEM OFF), and damage or looseness corrected. The system should be reprobbed after any repairs, changes, or corrections have been effected.

4. MEASUREMENT ACCURACY LIMITATIONS AND PRECAUTIONS.

a. The accuracy of the measurements made with the leakage probe system discussed here has been severely compromised in the interest of simplicity and operational dependability. Using the selection chart correction factors and depending upon a nominal ± 0.2 dB accuracy in both the power meters and

Microwave Leakage Probe System

attenuator (if required), the overall measurement accuracy of the system is ± 2.0 dB. For example: a leakage indication of 1.0 mW/cm^2 could lie in the real range from 0.6 to 1.6 mW/cm^2 . Better accuracy could be obtained by using a range of correction factors for each frequency band; however, leakage that occurs in even the highest power systems can readily be controlled to less than 1.0 mW/cm^2 . There is, consequently, no reason to require greater accuracy, since this proposed leakage probe system will suffice to maintain radiated levels at much below 10 mW/cm^2 .

b. The leakage probe system should only be used for its intended purpose. Measurement of the radiation levels associated with antenna main beams or spillover regions, etc., requires a greater accuracy, and at times, a lower gain (near isotrope) antenna to protect the investigator from exposure to potentially hazardous power density levels. The radiation protection program for free space radiating systems is specifically based on prohibiting personnel access to the radiation zones of such systems. The recommendations of this document are consistent with such a program; consequently, this leakage probe system is designed for use on nonradiating systems, or a nonradiating portion of a radiating system.

c. The following general recommendations should be part of the Standing Operating Procedure (SOP) for use of this leakage probe system.

(1) Specify those systems for which leakage probing is a requirement. Include all details as to when probing shall be done, how often, and what components of each system are affected.

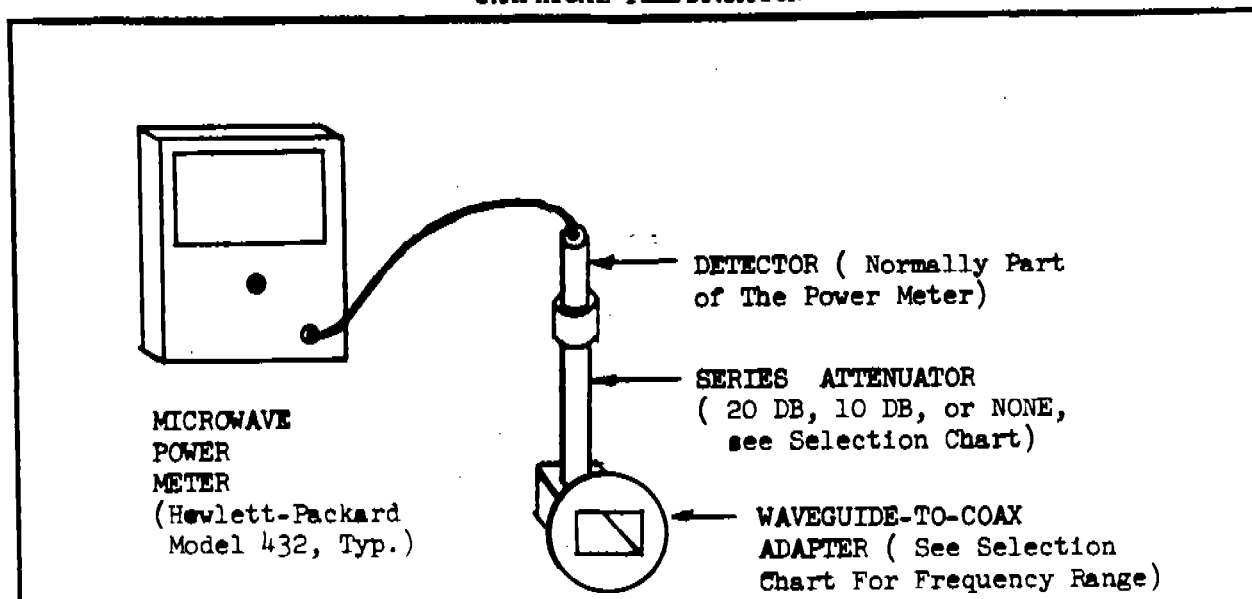
(2) Designate personnel responsible to do leakage probing and verify their capability.

(3) Maintain a permanent record (log book, etc.) of the use of leakage probing. Include all necessary details and results of the measurements.

(4) Document all aspects of the SOP.

d. Contact this Agency if further clarification is required either in the technical aspects of this document or the proper and safe procedures necessary to perform such tests. Further information can be obtained by writing Commander, US Army Environmental Hygiene Agency, ATTN: HSE-RL, Aberdeen Proving Ground Ground, MD 21010, or by calling AUTOVON 584-3932/3468.

GRAPHICAL ILLUSTRATION



SCHEMATIC DIAGRAM - - LEAKAGE PROBE SYSTEM

COMPONENT SELECTION CHART

LEAKAGE PROBE SYSTEM

FREQUENCY BAND (GHz)	1.12-1.70	1.70-2.60	2.60-3.95	3.95-5.85	5.30-8.20	7.05-10.0	8.2-12.4	12.4-18.0
WAVEGUIDE TYPE (WR - NOMENCLATURE)	WR-650	WR-430	WR-284	WR-187	WR-137	WR-112	WR-90	WR-62
WAVEGUIDE DIMENSION (INSIDE) CM.	.83 X 16.5	5.5 X 10.9	3.4 X 7.2	2.2 X 4.8	1.6 X 3.5	1.3 X 2.9	1.0 X 2.3	0.8 X 1.6
SERIES ATTENUATOR REQUIREMENT	20 DB	10 DB	10 DB	10 DB	NONE	NONE	NONE	NONE
CORRECTION FACTOR (mW to mW/cm ²)	.0065	.0148	.0361	.0840	.158	.235	.385	.690
INDICATED POWER* (FOR 1.0 mW/cm ²)	1.54 mW	6.70 mW	2.77 mW	1.20 mW	6.33 mW	4.26 mW	2.60 mW	1.45 mW

* INDICATED POWER TIMES A SERIES ATTENUATOR CORRECTION GIVES ACTUAL POWER. EXAMPLE: 1.54 mW X 100 = 154 mW, actual

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UNITED STATES ARMY MEDICAL DEPARTMENT

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